BUREAU OF ENVIRONMENTAL HEALTH
Emergency Response/Indoor Air Quality Program

Use of Moisture Measuring Devices in Evaluating Water Damage in Buildings

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The evaluation of mold colonization of building materials can present challenges particularly if no visible colonization or mold associated odors are present inside a building. "In most cases, if visible mold growth is present, sampling is unnecessary" (US EPA, 2001). Mold colonization is in fact **a manifestation of water damage** to building materials. Mold growth can occur for three general reasons: (1) water is unintentionally entering the building envelop[1] or is released from the plumbing system; (2) materials that can support mold colonization are placed in a location that is likely to become moistened[2] or (3) long periods of hot, humid weather (that occur in New England) results in persistent moistening of materials that can support mold colonization.

In all of these cases, the extended contact of water in either its liquid or vapor phase with a material prone to mold colonization creates the conditions that result in fungal growth indoors. For this reason, the conditions of chronic dampness inside of a building are addressed in 105 CMR 410.000: Minimum Standards of Fitness for Human Habitation (State Sanitary Code, Chapter II), which can be used to address mold growth indoors.

[1] The building envelop is the roof, exterior walls, doors/fenestrations and foundation that is designed to maintain the watertightness of the interior of a building.
[2] Example: boxes of personal belongs stored on the floor of a basement that is equipped with a sump pump in the floor.

While water staining or pooling water is an obvious source of moisture, means to objectively determine if a building material that is prone to mold colonization is wet are now available. The use of a moisture measuring device (MMD) can be used to detect the concentration of moisture in a building material. Using weather data to determine the last rain event prior to the assessment can provide clues as to how long building materials have been moist. The following is guidance concerning the use of MMDs to determine moisture concentrations in building materials and the likely presence of fungal growth on such materials.

The Moisture Measuring Devices (MMD)

The MMD operates on the principle of measuring electrical resistance. Different materials (e.g., gypsum wallboard, plaster, wood and other materials) generally will not readily conduct an electrical current. The addition of water to these materials increases the electrical conductivity (and decreases resistance). The MMD derives its measurement by detecting the conductivity of electricity through the sampled material. The pins of the MMD provide two ends of an electrical circuit; when inserted into a wet material, the circuit is created. The strength of the electrical current determines the percent of moisture in the sampled material. These devices either have pins or are pinless, but both operate using the same principle. All types examined are battery powered. Water content of sampled materials is expressed in a percentage. For ease of recording sampling data, it is recommended that a digital readout type of MMD be used. MMDs can be used to ascertain moisture levels in plaster, wood, gypsum wallboard (GW), concrete and brick. MMDs can also be used in other materials to ascertain moisture presence, such as wall-to-wall carpeting. In these instances, it is recommended that the MMD be set to the “wood” setting.

Sampling Methodology

In general, moisture sampling indoors should be conducted in a minimum of two separate discreet locations. A sample should be taken of the suspect materials as well as in a location that is not suspected of being a moisture problem (the control location) and does not contain any source of moisture intentionally introduced into the building (e.g., bathrooms, kitchens, custodial closets, washer/clothes dryer locations). The testing in the control location is necessary for comparison to the areas of suspected building component moistening.

Moisture in building materials usually is due to either direct exposure to water or water vapor/steam. According to the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), relative humidity greater than 70% can provide a sufficient airborne concentration of water vapor to moisten building materials. This becomes important when sampling for moisture. If the sampling is conducted in hot, humid weather, the relative humidity of the ambient air may be sufficient to indicate water content of sampled materials.

As part of any moisture sampling protocol, the temperature and relative humidity should be measured outdoors and indoors in an unaffected area as well as in the area of moisture concern. The temperature and relative humidity sampling should be conducted using a thermo hygrometer.

Sampling Protocols

The most common water damaged materials that the MMD can be used to detect moisture content in is gypsum wallboard (GW) and carpeting. The measuring of moisture content on other porous materials (plaster and wood) can be ascertained; however, the materials that are

moistened for longer the 24 to 48 hours without drying (e.g., GW, carpeting and ceiling tiles) are the materials most capable of supporting fungal growth that can impact indoor air quality. The following are moisture sampling protocols that have been used by ER/IAQ staff to determine if these materials should be removed.

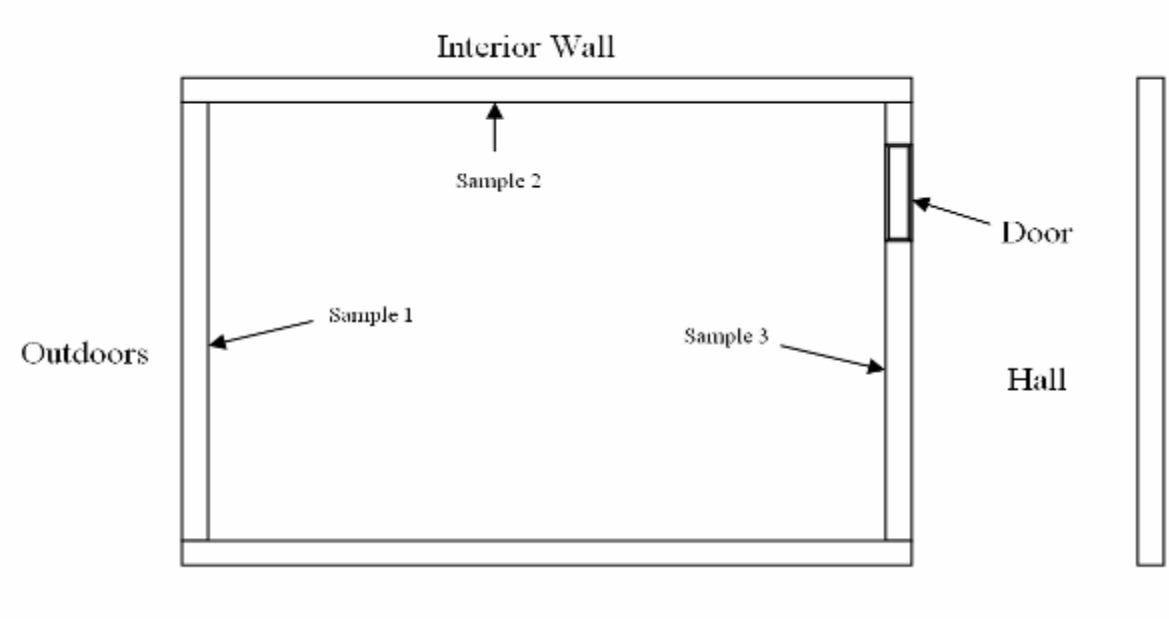
Gypsum Wallboard (GW)

Sampling of GW with no visible mold growth or water damage

In the case where water damage is not visible and no obvious water leak/flooding event has occurred, sampling for water content of building materials should be conducted in a comprehensive manner to determine whether the moisture content of GW is uniform throughout the building due to atmospheric relative humidity or whether a less obvious source moistening the GW (e.g., intermittent window leak) exists in a given location. In this instance, it is recommended that as many rooms as possible/feasible within a building are sampled so that a sufficient number of moisture measurements can be used to help determine whether a pattern can be seen. Each location that is the focus of the moisture investigation should be sampled in a minimum of three locations: (1) the area of suspected water damage (usually an exterior wall); (2) the center of an interior wall between the exterior and (3) hallway walls and the hallway wall (Figure 1).

By sampling three separate locations in a room, the moisture content can be compared to determine if a location contains more moisture than other GW walls in a room. The results can then be entered to a chart by which the moisture content in walls can be compared. An example of moisture measurements in GW are provided in Table 1.

Figure 1: Sample Locations for GW

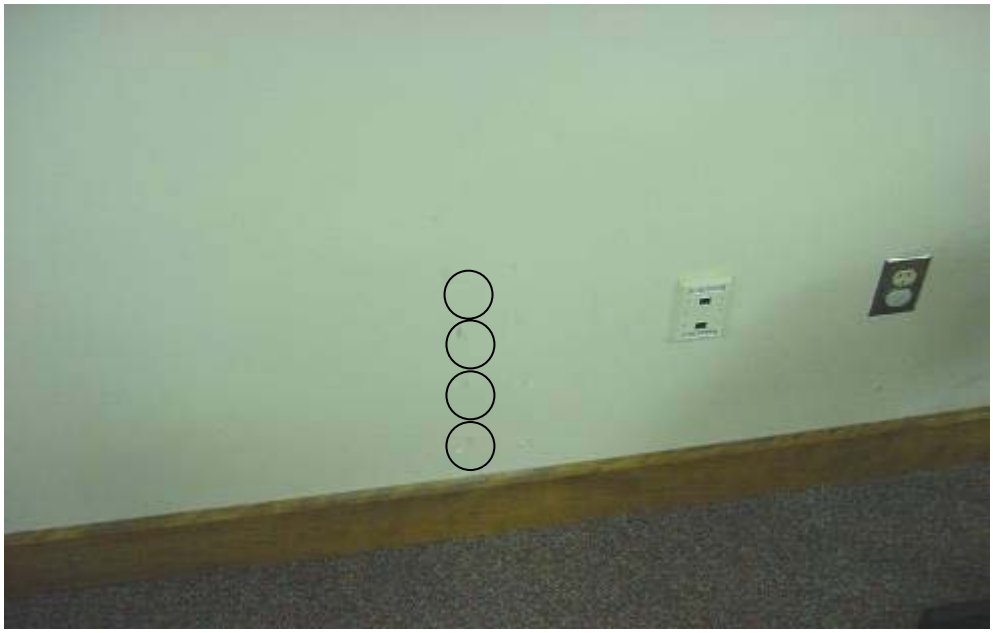


Once recorded, moisture sampling data can be compared to the control area sample. In general, if the majority of moisture measurements fall with a range of +/ 0.3 percent, it is likely that the source of moisture measured in the GW is a result of atmospheric relative humidity, and not considered unusual.

Sampling of GW with visible water damage, but no mold growth

Initially, GW should be sampled in an area not involved with the flooding, preferably in non-affected areas. GW readily absorbs moisture when in contact with flood water. Since GW is a layer of crushed gypsum between sheets of heavy paper, water can move by capillary action to moisten a significant amount of wall material above the flood level. When sampling GW, sampling should begin at the base of the wall (Picture 1); each subsequent sample should be taken in regular intervals (~ 3 inches apart) up the wall.

Picture 1



Moisture samples in GW of finished basement (circles note sample locations)

Picture 2

Marking on GW indicating height of moisture above background

When moisture measurements roughly match (within a range of +/- 0.3 percent), mark the area with a pencil to indicate the height of the level of moistened GW (Picture 2).

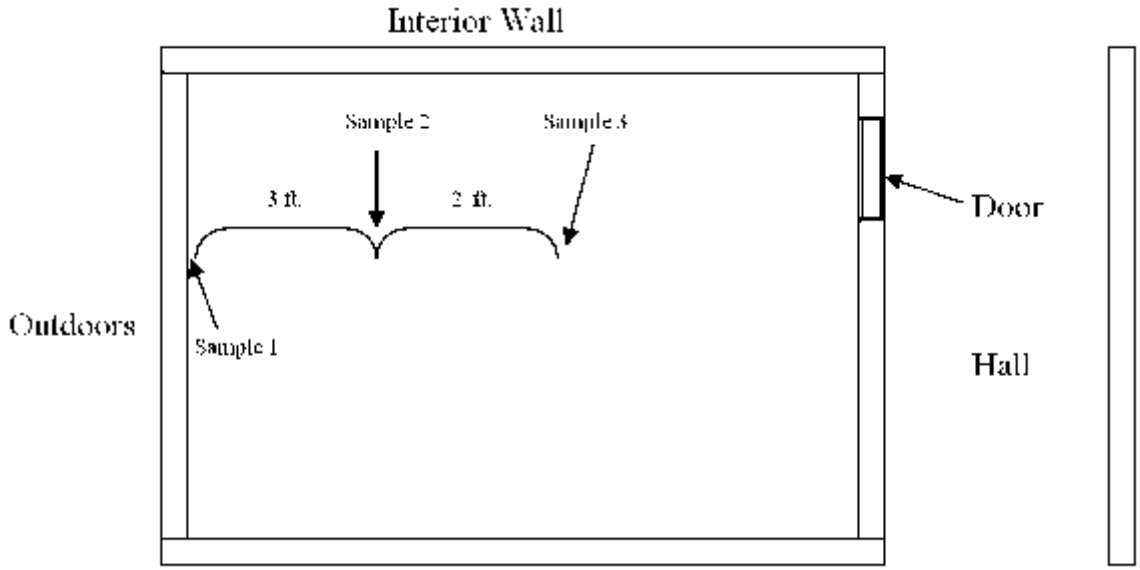
Carpeting[3]

The procedure used to measure moisture in carpeting is similar to that of GW in a flood situation. A control sample should be taken in an area not involved with the water damage, preferably on a floor above the suspect area. The carpet should have moisture samples taken in rooms throughout the building at three distance intervals. The MMD should be placed on /inserted into the surface of carpeting (1) directly over the wall/slab seam on an exterior wall/on the location of suspected water damage; (2) approximately 3 feet away from the first location and (3) if moisture was detected in the 3 feet measurement, a third reading should be taken approximately 5 feet from the first location (Figure 2).

This process can be repeated at two foot intervals until measurements are either equal to the control measurement or non-detectable. Please note that if a source of moisture in the carpet were atmospheric (e.g., increase relative humidity), moisture readings in carpet would be expected to be relatively uniform (i.e., with a narrow variation of $\pm$ 2%) throughout the carpet measured. Where a significant variation exists in moisture content (e.g., one section of carpet measures non-detectable for moisture, another section measures 10%), it could be concluded that another source of water is moistening the carpet. An example of moisture measurements in carpet are provided in Table 2.

[3] MMDs can be used to ascertain moisture levels in plaster, wood, gypsum wallboard (GW), concrete and brick. MMDs can also be used in other materials to ascertain moisture presence, such as wall-to-wall carpeting, in this instance, it is recommended to set the MMD the "wood" setting, which will provide results in a range of 0-15 percent as the non-moistened range.

Figure 2: Sample Locations for Carpet



Interpretation of Moisture Measurement Data

Once moisture measurements are taken and the source of moisture is suspected to be related to a weather event, the following procedures should be followed:

1. Obtain historic weather data to determine the last significant rainfall in the general area of the building (there exists a number of on-line historic data resources). Be sure to note the amount of rainfall and general wind direction of the last significant rainfall prior to the sampling.
2. In the absence of plumbing failure or high relative humidity, one can draw the conclusion that the rainfall is the source of the moisture measured inside the building due to a breach in the building envelop.
3. If the rainfall occurred 24 to 48 hours or more prior to the moisture sampling, a conclusion can be made that the building materials with elevated moisture readings should be removed

if it is a porous surface (e.g., GW, carpeting, ceiling tiles) If the areas moistened are wet for more than 24 hours, these materials should be removed/replaced (Table 3).

Remediation of Moistened Materials

Mold contaminated materials should be removed in a manner to prevent cross contamination of clean areas of a building in order to minimize exposure to building occupants. Such removal should be done in a manner consistent with the most current guidelines established by the US Environmental Protection Agency document entitled "Mold Remediation in Schools and Commercial Buildings." This document can be downloaded at the following web address: http://www.epa.gov/iaq/molds/mold_remediation.html

Questions

If you have any questions concerning these guidelines, please contact:

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References

US EPA. 2001. Mold Remediation in Schools and Commercial Buildings. US Environmental Protection Agency, Office of Air and Radiation, Indoor Environments Division, Washington, D.C. EPA 402-K-01-001. March 2001. http://www.epa.gov/iaq/molds/mold_remediation.html

Table 1

Sample Data Table for GW

Location	Temp	Relative Humidity (%)	Exterior Wall Moisture (%)	Interior Wall Moisture (%)	Exterior Wall Moisture (%)	Highest Moisture (%)	Location Highest (%)
305	71	70	**0.9**	0.3	0.3	**0.9**	Beneath window frame
306	71	59	0.3	0.3	0.3	0.3	
307	70	72	0.3	0.2	0.3	0.3	
308	71	70	**1.5**	0.3	0.4	**1.5**	Beneath window frame
415	72	61	0.3	0.3	0.3	0.3	
413	73	60	0.3	0.2	0.3	0.3	
419	72	61	0.3	0.3	0.3	0.3	
101*	73	61	0.2	0.2	0.2	0.2	

* Location chosen as the control moisture measurement (an interior room without windows

Example, it would appear that Rooms 305 and 308 have moistened GW, since two samples are significantly higher when compared to the control samples and other rooms sampled. The location of the higher percentage moisture measurements may indicate water leaking through the window frames in these areas.

Table 2

Sample Data Table for Carpeting

Area	Moisture reading in carpet at wall/slab seam %	Moisture reading in carpet 3' from wall/slab seam %	Moisture reading in carpet 5' from wall/slab seam %
217	ND	ND	ND
225	9	ND	ND
226	9	ND	ND
227	ND	ND	ND
213	12	ND	ND
326	ND	ND	ND
328	15	ND	ND
212	9	ND	ND
320	13	ND	ND
318	10	ND	ND
319	10	8	ND
315	8	ND	ND
317	9	ND	ND
306	19	10	3
414	21	20	10
415	18	13	ND
422	25	ND	ND

ND = non detectable

In this example, all carpeting should have non-detectable levels of moisture. These results would indicate possible water penetration through the exterior wall of the building along the floor/interior wall seams

Table 3

U.S. Environmental Protection Agency "Mold Remediation in Schools and Commercial Buildings": Investigating, Evaluating, and Remediating Moisture and Mold Problems

Water Damage - Cleanup and Mold Prevention

Table 1 presents strategies to respond to water damage within 24-48 hours. These guidelines are designed to help avoid the need for remediation of mold growth by taking quick action before growth starts. If mold growth is found on the materials listed in **Table 1**. Depending on the size of the area involved and resources available, professional assistance may be needed to dry an area quickly and thoroughly.

Table 1: Water Damage - Cleanup and Mold Prevention	
Guidelines for Response to Clean Water Damage within 24-48 Hours to Prevent Mold Growth*	
Water-Damaged Material†	**Actions**
Books and papers	• For non-valuable items, discard books and papers. • Photocopy valuable/important items, discard originals. • Freeze (in frost-free freezer or meat locker) or freeze-dry.
Carpet and backing - dry within 24-48 hours§	• Remove water with water extraction vacuum. • Reduce ambient humidity levels with dehumidifier. • Accelerate drying process with fans.
Ceiling tiles	• Discard and replace.
Cellulose insulation	• Discard and replace.
Concrete or cinder block surfaces	• Remove water with water extraction vacuum. • Accelerate drying process with dehumidifiers, fans, and/or heaters.
Fiberglass insulation	• Discard and replace.
Hard surface, porous flooring§ (Linoleum, ceramic tile, vinyl)	• Vacuum or damp wipe with water and mild detergent and allow to dry; scrub if necessary. • Check to make sure underflooring is dry; dry underflooring if necessary.
Non-porous, hard surfaces (Plastics, metals)	• Vacuum or damp wipe with water and mild detergent and allow to dry; scrub if necessary.

Table 1: Water Damage - Cleanup and Mold Prevention	
Upholstered furniture	• Remove water with water extraction vacuum. • Accelerate drying process with dehumidifiers, fans, and/or heaters. • May be difficult to completely dry within 48 hours. If the piece is valuable, you may wish to consult a restoration/water damage professional who specializes in furniture.
Wallboard (Drywall and gypsum board)	• May be dried in place if there is no obvious swelling and the seams are intact. If not, remove, discard, and replace. • Ventilate the wall cavity, if possible.
Window drapes	• Follow laundering or cleaning instructions recommended by the manufacturer.
Wood surfaces	• Remove moisture immediately and use dehumidifiers, gentle heat, and fans for drying. (Use caution when applying heat to hardwood floors.) • Treated or finished wood surfaces may be cleaned with mild detergent and clean water and allowed to dry. • Wet paneling should be pried away from wall for drying.
* Even if materials are dried within 48 hours, mold growth may have occurred. Items may be tested by professionals if there is doubt. Note that mold growth will not always occur after 48 hours; this is only a guideline. These guidelines are for damage caused by clean water. If you know or suspect that the water source is contaminated with sewage, or chemical or biological pollutants, then Personal Protective Equipment and containment are required by OSHA. An experienced professional should be consulted if you and/or your remediators do not have expertise remediating in contaminated water situations. Do not use fans before determining that the water is clean or sanitary. † If a particular item(s) has high monetary or sentimental value, you may wish to consult a restoration/water damage specialist. § The subfloor under the carpet or other flooring material must also be cleaned and dried. See the appropriate section of this table for recommended actions depending on the composition of the subfloor.	